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Fish and Wildlife Research 14

Residues and Trends of Organochlorine Pesticide and Polychlorinated Biphenyls in Birds From Texas, 1965–88

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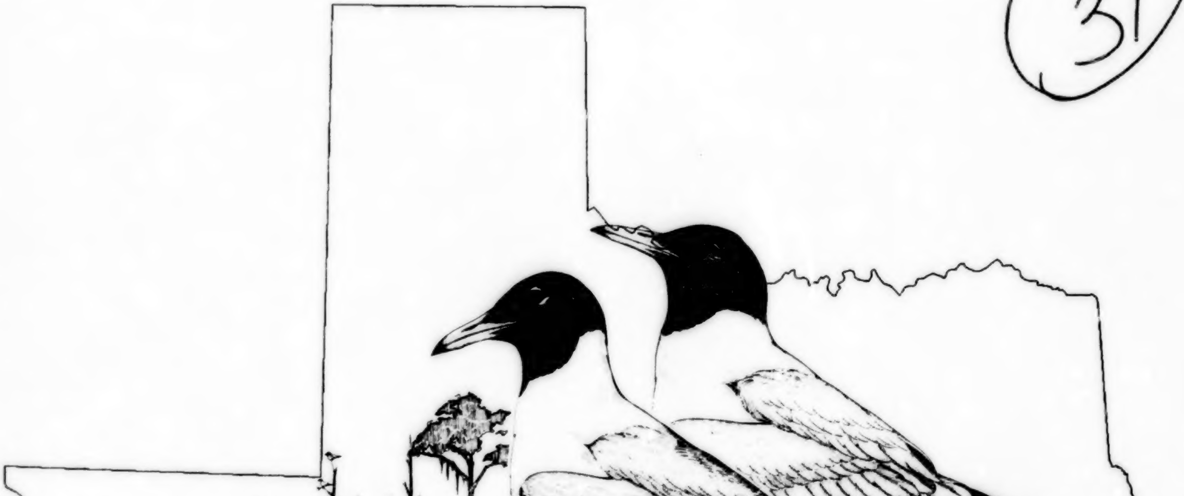

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Fish and Wildlife Research 14

Residues and Trends of Organochlorine Pesticide and Polychlorinated Biphenyls in Birds From Texas, 1965–88

By Miguel A. Mora

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Residues and Trends of Organochlorine Pesticide and Polychlorinated Biphenyls in Birds From Texas, 1965–88

by

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Abstract. Concentrations of DDE (a metabolite of DDT) in birds decreased during recent years in most areas of the continental United States. Organochlorine pesticides were widely used in agriculture in Texas from the early 1950s to the 1970s. I used previously published data to determine whether concentrations of DDE and polychlorinated biphenyls (PCBs) in birds from Texas have followed a decreasing trend similar to that in birds from other areas in the United States. A total of 2,669 bird samples was collected between 1965 and 1988 from diverse locations in Texas and was analyzed for organochlorines and other environmental contaminants. The brown pelican (*Pelecanus occidentalis*), peregrine falcon (*Falco peregrinus*), laughing gull (*Larus atricilla*), black skimmer (*Rynchops niger*), and European starling (*Sturnus vulgaris*) were the most frequently studied species. DDE and PCBs were the most commonly detected organochlorines in bird tissues. Mean DDE concentrations ranged from 0.04 to 61.00 parts per million (ppm) wet weight (ww) and PCBs from 0.02 to 32.00 ppm ww. Concentrations of DDE in eggs and carcasses of black skimmers decreased significantly during 1970–84 and dropped from approximately 10 to nearly 3 ppm ww. PCBs decreased from approximately 7 ppm ww to 1 ppm ww in eggs and carcasses. DDE concentrations in eggs of brown pelicans varied from more than 3 ppm ww in 1970 to approximately 1 ppm ww in 1983; and PCB concentrations diminished from about 10 to 1 ppm ww. Decreasing trends in concentrations of DDE and PCBs were observed in most species, although in some cases, the estimated trends were not significantly different from zero. Concentrations of DDE in birds from the Texas coast decreased from more than 6.0 ppm in 1978 to below 0.5 ppm in 1985. The decreasing ratios in selected species varied from approximately 2.0 to 12.0 (DDE) and from 4.5 to 9.0 (PCBs). The results indicate that in general from 1965 to 1988, DDE and PCBs declined in birds from Texas.

Key words: Organochlorines, pesticides, birds, Texas, DDE, PCBs, trends.

Beginning in the 1940s, organochlorine pesticides (OCs) were used intensively in agriculture until the mid 1970s, when most of the highly persistent compounds such as DDT (1,1,1-trichloro-2,2-bis [P-chlorophenyl ethane]), dieldrin, toxaphene, and mirex were banned in the United States. Currently, other less persistent chemicals such as organophosphorus, carbamate, and synthetic pyrethroid pesticides are used in Texas in significant amounts (Texas Agricultural Extension Service [TAES], College Station, Texas, personal communication).

The eggshell thinning effects of DDE (2,2-bis[P-chlorophenyl]-1,1-dichloroethene), a metabolite of DDT, on birds were first documented by Ratcliffe (1967) in England. He observed that eggshells of some British raptors were thinner than normal, which increased egg breakage and reduced reproductive success. The eggshell thinning effects of DDE were soon thereafter documented in North American birds by Hickey and Anderson (1968). Experimental studies with birds in the laboratory provided strong evidence of a significant negative correlation between DDE and eggshell thinning (Heath et al. 1969; Porter and Wiemeyer 1969). The discovery of eggshell thinning from DDT and metabolite residues in bird eggs prompted many investigations of the potential effects of organochlorine pesticides on bird populations (Stickel 1973).

Many studies of contaminants in wildlife were conducted in Texas and some problems were detected. For example, the brown pelican (*Pelecanus occidentalis*) almost disappeared from the Texas Gulf coast by 1963, and an average of only 100 individuals was observed annually between 1967 and 1974 (King et al. 1977, 1985). This decline in numbers of brown pelicans was attributed largely to reproductive failure from DDE-induced eggshell thinning (Blus et al. 1974; King et al. 1985).

PCBs (Polychlorinated biphenyls) were usually analyzed in wildlife samples and reported with other persistent organochlorines. PCBs are chlorinated hydrocarbons of industrial origin that were used as insulator fluids in transformers and capacitors and also had many other uses. PCBs have been linked with teratogenic effects and behavioral changes in birds from the Great Lakes (Kubiak et al. 1989; Gilbertson et al. 1991).

I decided to evaluate the status and trends of organochlorines in birds from Texas because more than 20 years had elapsed since DDT was banned in the United States. I hypothesized that the concentrations of organochlorines, primarily DDE and PCBs, had decreased in birds from Texas to perhaps their lowest levels since the late 1960s and early 1970s. DDT was banned in 1972 and PCBs in 1978.

Methods and Materials

I compiled data on organochlorines in tissues of birds from articles published between 1965 and 1994. I also contacted researchers who had conducted investigations throughout Texas for additional information. Most data were presented similarly in each paper, that is, on a wet-weight (ww) basis by geometric rather than arithmetic means. The analytical techniques may have varied somewhat, but most of the chemical analyses were performed at the Patuxent Analytical Control Facility, Patuxent Wildlife Research Center, or by a contract laboratory under strict quality assurance and quality control procedures approved by the facility. The Patuxent Wildlife Research Center of the U.S. Fish and Wildlife Service was the leading governmental institution that conducted many laboratory and field studies on the effects of OCs in terrestrial wildlife. The lowest limits of detection of organochlorine pesticides ranged from 0.005 to 0.100 ppm and of PCBs, from 0.010 to 0.500 ppm. In about half the studies, the detection limits of organochlorine pesticides were 0.1 ppm and the detection limits of PCBs were 0.5 ppm.

To analyze the compiled information, I assumed that despite intrinsic differences in the sampling variables, such as year, season, species, and location, overall statewide trends could still be assessed. The chemical and biological data were gathered by different scientists, at different times, in different locations, and from diverse species. Only in few cases were the same species sampled for more than 1 year at a given location.

Regression analyses were carried out to test for relations between mean concentrations of DDE and PCBs and sampling year. The interpretation of these relations should be taken with caution because the same locations were not monitored in a continuous manner, and most of the observed differences could be species and time related. An alternative test (sign test) was also performed with the slopes of the regression lines and with data from 10 species. I tested the hypothesis that half the slopes were negative and half were positive to determine whether declining trends in concentrations of DDE and PCBs were evident in more than half the species.

Results

A total of 2,669 samples from 51 species (carcasses, eggs, blood, wings, and brains) was collected in Texas and analyzed for OCs between 1965 and 1988 (Table 1). The brown pelican (*Pelecanus occidentalis*), peregrine falcon (*Falco peregrinus*), laughing gull (*Larus atricilla*), black skimmer (*Rynchops niger*), and European starling (*Sturnus vulgaris*) were the most frequently studied species (Table 1). More than 90% of the samples were eggs and carcasses. Approximately 34% of the samples were from the Laridae family (gulls, terns, and skimmers) and only two other families, Sturnidae and Scolopacidae, represented more than 10% of the samples (Table 2). Field studies were scattered throughout Texas in 26 counties and in some undisclosed locations, however, most studies were conducted along the Gulf coast. More than 70% of the samples were from the coastal counties of

Table 1. Type and number of samples that were analyzed for organochlorines by species.[a]

Species	Carcass	Egg	Blood	Wing	Brain	Total
Pied-billed grebe[1] (*Podilymbus podiceps*)	2					2
American white pelican[2,4] (*Pelecanus erythrorhynchos*)	1	5				6
Brown pelican[2,3] (*Pelecanus occidentalis*)		114				114
Double-crested cormorant[5] (*Phalacrocorax auritus*)	20					20
Neotropic cormorant[2,6,7,39] (*Phalacrocorax brasilianus*)	20	43				63
Great blue heron[2,8] (*Ardea herodias*)		53				53
Great egret[2] (*Casmerodius albus*)		10				10
Snowy egret[2] (*Egretta thula*)		10				10
Little blue heron[2] (*Egretta caerulea*)		5				5
Tricolored heron[2] (*Egretta tricolor*)		5				5
Reddish egret[2] (*Egretta rufescens*)		10				10
Black-crowned night-heron[2,9] (*Nycticorax nycticorax*)		20				20
White ibis[2] (*Eudocimus albus*)		5				5
White-faced ibis[2,11,12] (*Plegadis chihi*)		66				66
Roseate spoonbill[2,10] (*Ajaia ajaja*)		80				80
Fulvous whistling-duck[13] (*Dendrocygna bicolor*)	21					21
Snow goose[18] (*Chen caerulescens*)					12	12
Green-winged teal[15] (*Anas crecca*)	10				4	14
Mallard[9,15,16,17,31] (*Anas platyrhynchos*)	34			46		80
Northern pintail[15] (*Anas acuta*)	14				3	17
Blue-winged teal[14] (*Anas discors*)	61					61

Table 1. *Continued.*

Species	Carcass	Egg	Blood	Wing	Brain	Total
Redhead[40] (*Aythya americana*)	40					40
Peregrine falcon[19] (*Falco peregrinus*)			154			154
American coot[9] (*Fulica americana*)	20					20
Black-necked stilt[4] (*Himantopus mexicanus*)	3					3
American avocet[20,21] (*Recurvirostra americana*)	34					34
Greater yellowlegs[20] (*Tringa melanoleuca*)	2					2
Lesser yellowlegs[20] (*Tringa flavipes*)	17					17
Willet[22] (*Catoptrophorus semipalmatus*)	55					55
Sanderling[20] (*Calidris alba*)		15				15
Western sandpiper[20,21] (*Calidris mauri*)	102					102
Least sandpiper[20] (*Calidris minutilla*)	30					30
Dunlin[20] (*Calidris alpina*)	13					13
Long-billed dowitcher[21] (*Limnodromus scolopaceus*)	55					55
Laughing gull[1,2,6,23] (*Larus atricilla*)	59	251				310
Franklin's gull[1] (*Larus pipixcan*)	6					6
Ring-billed gull[1] (*Larus delawarensis*)	26					26
Herring gull[1] (*Larus argentatus*)	2					2
Gull-billed tern[2] (*Sterna nilotica*)		10				10
Caspian tern[2] (*Sterna caspia*)		10				10
Royal tern[2,24] (*Sterna maxima*)		50				50
Sandwich tern[2] (*Sterna sandvicensis*)		5				5
Forster's tern[1,2,25] (*Sterna forsteri*)	1	81				82
Least tern[2] (*Sterna antillarum*)		5				5
Black skimmer[2,6,25,26,27,28,29] (*Rynchops niger*)	45	366				411
Western kingbird[9] (*Tyrannus verticalis*)	111					111
Barn swallow[41] (*Hirundo rustica*)		10				10
European starling[17,30,32,33,34,35,36,37,38] (*Sturnus vulgaris*)	347					347
Red-winged blackbird[1] (*Agelaius phoeniceus*)	1					1

Table 1. *Continued.*

Species	Carcass	Egg	Blood	Wing	Brain	Total
Great-tailed grackle[1] (*Quiscalus mexicanus*)	10					10
House sparrow[9,b] (*Passer domesticus*)	59					59
Total	1,221	1,229	154	46	19	2,669
Percent	45.7	46.0	5.8	1.7	0.7	99.9

[a] Pooled data from Hunt et al. 1986 are not included in this table, but are given in appendix. Also, data from birds found dead or moribund were not included in the analysis of trends.

[b] Approximately 75–90 sparrows collected during 1965 at Presido, Texas, are not included in this total because the exact number of samples was not indicated in the study (Culley and Applegate 1967).

References: [1] White et al. 1983a, [2] King et al. 1978, [3] King et al. 1985, [4] Gamble et al. 1988, [5] King et al. 1987, [6] King & Krynitsky 1986, [7] King 1989a, [8] Mitchell et al. 1981, [9] White & Krynitsky 1986, [10] White et al. 1982, [11] King et al. 1980, [12] Custer & Mitchell 1989, [13] Flickinger et al. 1986, [14] White et al. 1981, [15] Flickinger & Krynitsky 1987, [16] White & Heath 1976, [17] White 1979a, [18] Flickinger 1979, [19] Henny et al. 1988, [20] White et al. 1980, [21] White et al. 1983c, [22] Custer & Mitchell 1991, [23] White et al. 1983b, [24] King et al. 1983, [25] King et al. 1991, [26] Custer & Mitchell 1987, [27] King 1989b, [28] White et al. 1984, [29] White et al. 1985, [30] Bunck et al. 1987, [31] Cain 1981, [32] Martin & Nickerson 1972, [33] Nickerson & Barbehenn 1975, [34] White 1976, [35] Cain & Bunck 1983, [36] Bunck unpubl., [37] Martin 1969, [38]White 1979b, [39]Morrison 1978, [40]Michot et al. 1994, [41] King et al. 1994.

Calhoun, Cameron, Galveston, Nueces, and Willacy (Table 3; Fig. 1).

DDE and PCBs were the predominant OCs in bird tissues (Table 4). DDE was detected in almost all the samples. DDE was not reported in two studies of waterfowl (fulvous whistling-ducks *[Dendrocygna bicolor*] and snow geese [*Chen caerulescens*]) because those studies were focused on dieldrin and endrin and because other OCs were low or non-detected (Flickinger 1979; Flickinger et al. 1986). Overall, mean DDE concentrations ranged from 0.04 to 61.00 ppm ww. The maximum geometric mean DDE value was observed during 1982 in carcasses of western kingbirds (*Tyrannus verticalis*) from Reeves and Hudspeth counties (Hunt et al. 1986). High DDE values were also observed during 1979 in laughing gulls from the lower Rio Grande valley (White et al. 1983a). PCBs were detected in about two-thirds of the samples and reached a maximum concentration of 32 ppm ww. The highest mean concentrations of OCs in birds from Texas during 1965–88 ranged from 0.1 to 61.0 ppm ww (Table 5). Values from dead or moribund birds are reported below.

Table 2. Family distribution of bird species (tissues) in studies of organochlorine contents in birds from Texas.

Family	Total	Percent
Podicipedidae	2	0.1
Pelecanidae	120	4.5
Phalacrocoracidae	83	3.1
Ardeidae	193	7.2
Threskiornithidae	71	2.7
Anatidae	245	9.2
Falconidae	154	5.8
Rallidae	20	0.7
Recurvirostridae	37	1.4
Scolopacidae	289	10.8
Laridae	917	34.3
Tyrannidae	111	4.2
Hirundinidae	10	0.4
Sturnidae	347	13.0
Emberizidae	11	0.4
Passeridae	59	2.2

Organochlorines other than DDE and PCBs were detected less frequently in bird tissues and at lower concentrations than DDE and PCBs (Table 4). Dieldrin was the third most common OC and was detected at relatively low concentrations (≤0.8 ppm), except in two cases in which dead or moribund birds had been poisoned with dieldrin (Flickinger 1979). The geometric mean of dieldrin in all samples was 0.22 (range 0.005–3.800) ppm ww. The highest concentration of dieldrin in a live, apparently normal specimen was found in 1972 in the breast muscle of a snow goose feeding near fields that had been planted with aldrin-

Table 3. Number of samples from different Texas counties.

County or region	Carcass	Egg	Blood	Wing	Brain	Total
Aransas	20					20
Bastrop	10					10
Bexar	17					17
Brazoria	27					27
Calhoun	54	134				188
Cameron	106	163	154			423
Castro	40					40
Clay	70					70
Cochran	30					30
Comal	40					40
Culberson	30					30
El Paso	30					30
Galveston	90	179				269
Hale	20					20
Hudspeth	30					30
Kinney	50					50
Morris	10					10
Nacogdoches	20					20
Nueces	103	293				396
Pecos	34					34
Presidio	20					20
Reeves	30					30
Rusk		10				10
San Patricio	50					50
Wharton	21					21
Willacy	221	120				341
Playa Lakes	38				19	57
Gulf coast		315				315
Unknown	10	15		46		71

treated rice seed in the Garwood Prairie (Flickinger 1979; Table 5). Dead snow geese collected during 1972 and 1974 in the Garwood Prairie had average (arithmetic) dieldrin brain concentrations of 15.6 ppm ($n = 14$); and moribund snow geese had average dieldrin concentrations of 8.5 ppm ($n = 8$) in brain. Dieldrin residues averaged 3.1 ppm ($n = 8$) in dead fulvous whistling-ducks found in rice fields during 1960–69 (Flickinger et al. 1986).

Heptachlor epoxide was detected at relatively low concentrations (≤1 ppm ww) in more than 20% of the samples (Table 4). The overall geometric mean was 0.23 (range 0.006–2.350) ppm ww. Only three samples (2 brains and 1 carcass) had concentrations above 1.0 ppm ww. Toxaphene, another highly persistent organochlorine, was detected in more than 15% of the samples at concentrations of usually below 1.0 ppm ww. The overall geometric mean was 0.32 (range 0.06–1.70) ppm ww. Toxaphene may have not been reported in many cases because of the difficulty of separation and quantification (Bidleman et al. 1993; Schantz et al. 1993). Chlordane, another organochlorine, was detected at low concentrations in more than 10% of the samples. Chlordane isomers, hexachlorobenzene, DDD, and DDT were detected also at relatively low concentrations in a smaller percentage of samples (Table 4).

Trends of DDE and PCB Concentrations in Selected Species

Overall, all slopes of the linear relations between DDE and year of sampling were negative. Consequently, the null hypothesis of half negative and half positive slopes was rejected in favor of the alternative of a trend of declining DDE concentrations in significantly ($P < 0.01$) more than half the species (with enough data points). Similarly, negative slopes from data of significantly ($P < 0.05$) more than half the

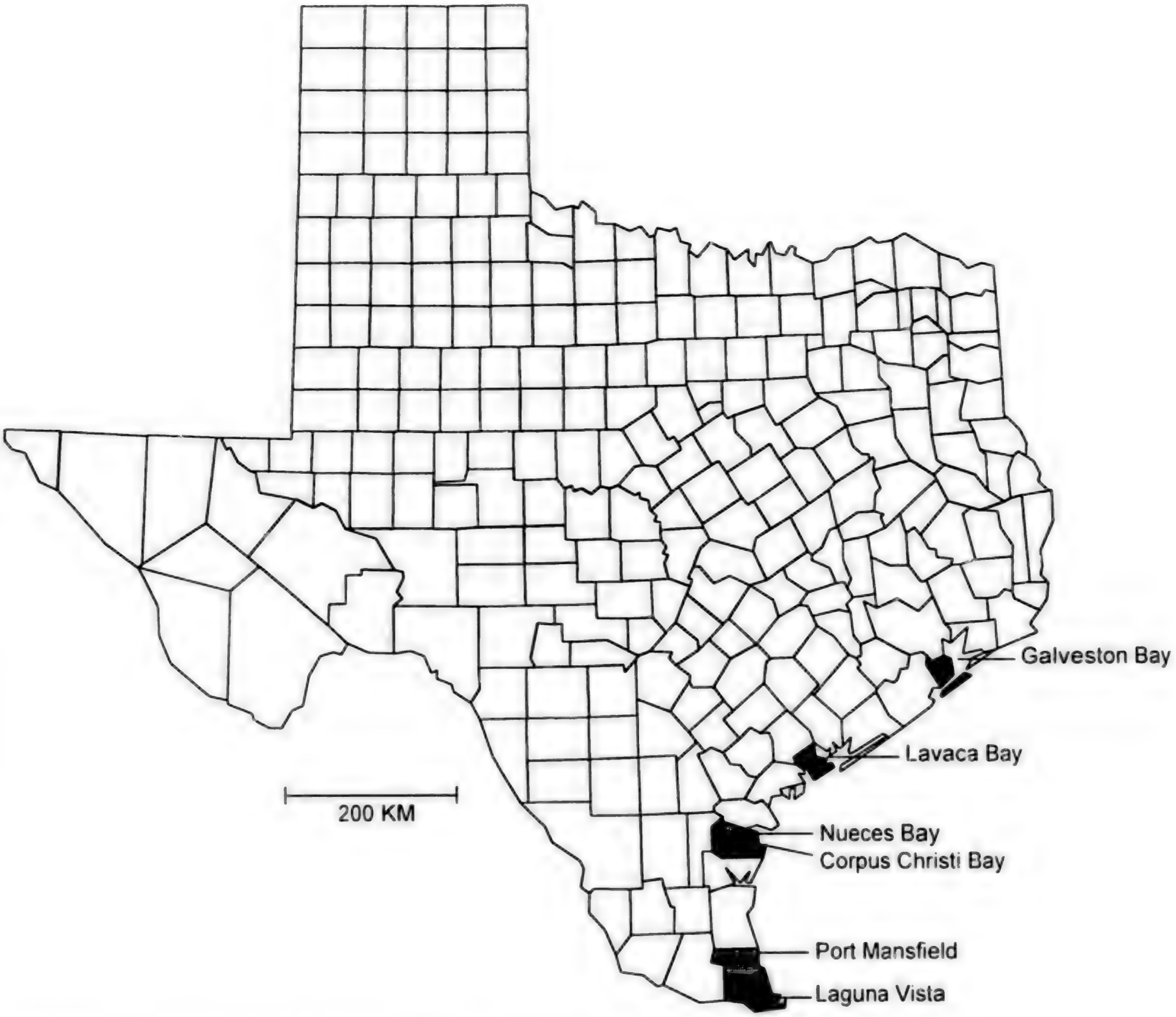

Fig. 1. Texas; counties (*shaded*) and primary locations (*names*) where most studies were conducted.

Table 4. Percent occurrence of organochlorines in bird tissues.[a]

Chemical	*n*	Percent
DDE	2,600	97.4
PCBs	1,772	66.4
Dieldrin	1,029	38.6
Heptachlor epoxide	611	22.9
Toxaphene	442	16.6
Chlordane	343	12.9
DDD	226	8.5
Oxychlordane	221	8.3
DDT	208	7.8
Hexachlorobenzene	184	6.9
trans-Nonachlor	101	3.8
Endrin	72	2.7

[a] Total number of samples = 2,669.

species indicated a trend of declining PCB content. Information on some representative species and locations is provided in more detail.

Black Skimmer

The black skimmer was the most commonly selected species for studies of contaminants in Texas from 1970 to 1984 (King et al. 1978, 1991; White et al. 1984, 1985; King and Krynitsky 1986; Custer and Mitchell 1987; King 1989b). Carcasses and eggs were collected from selected areas in or near Galveston Bay, Lavaca Bay, Corpus Christi, Port Mansfield, and Laguna Vista and from a few undisclosed areas on the Gulf coast. A total of 411 samples (89% eggs, 11% carcasses) was analyzed.

Table 5. Highest mean (ppm ww) organochlorine values reported in birds from Texas, 1965–1988.[a]

Compound	Mean[b]	*n*	Year	Species[d]	Location	Reference
DDE	61.0	3	1982	Western kingbird[c]	Reeves/Hudspeth	Hunt et al. 1986
DDD	10.2[a]	6	1965	House sparrow[m]	Presidio County	Culley and Applegate 1967
DDT	7.0[a]	6	1965	House sparrow[m]	Presidio County	Culley and Applegate 1967
PCBs	32.0[a]	5	1970	Neotropic cormorant[e]	Coast	King et al. 1978
Hexachlorobenzene	0.2	10	1980	Neotropic cormorant[c]	Galveston Bay	King and Krynitsky 1986
Heptachlor epoxide	2.4	6	1981	Green-winged teal[c]	Playa Lakes	Flickinger 1987
Oxychlordane	0.1	6	1981	Green-winged teal[c]	Playa Lakes	Flickinger 1987
t-Nonachlor	0.2	10	1985	European starling[c]	Comal County	Bunck unpublished
Chlordane	1.0	2	1977	American avocet[c]	Corpus Christi	White et al. 1980
Endrin	0.3	1	1985	American white pelican[c]	Pharr Settling Basin	Gamble et al. 1988
Dieldrin	3.8[a]	6	1972	Snow goose[m]	Garwood Prairie	Flickinger 1979
Toxaphene	1.7	1	1978	Forster's tern[c]	Llano Grande	White et al. 1983

[a] Does not include concentrations in dead or moribund birds because these specimens were considered special cases.

[b] Geometric means unless indicated otherwise, a = arithmetic mean.

[c] c = carcass, e = egg, m = breast muscle, w = wing.

Data from carcasses were available only from the Galveston Bay (3 years) and from Port Mansfield (1 year). Overall, DDE concentrations were not significantly different between eggs and carcasses of black skimmers (Fig. 2A); samples were not from the same individuals or locations. Linear regression of annual means in eggs and carcasses combined indicated a significant negative relation or reduction in DDE concentrations from 1970 to 1984 ($r^2 = 0.55$, 9 df, $P = 0.009$). The negative correlation between DDE and sampling year was also significant ($r^2 = 0.31$, 14 df, $P = 0.025$) when individual rather than annual means were compared (Fig. 3A). If the concentrations in birds are analyzed separately by region, however, a significant negative association or reduction in concentrations in eggs existed only in specimens from Port Mansfield ($r^2 = 0.92$, 1 df, $P < 0.05$) and from Corpus Christi ($r^2 = 0.65$, 2 df, $P < 0.05$) but not from Laguna Vista or from the Galveston Bay. Overall, the concentrations of DDE in eggs of black skimmers dropped from approximately 10 ppm ww in 1970 to nearly 3 ppm ww in 1984 (Fig. 3A).

The concentrations of PCBs in eggs and carcasses of black skimmers followed a trend similar to that of DDE, but the values were lower than those of DDE (Fig. 2B). Similar to DDE, concentrations of PCBs were not significantly different between eggs and carcasses within years. Also, the negative correlation between concentrations of PCBs and year of sampling from 1970 to 1984 was significant ($r^2 = 0.42$, 9 df, $P = 0.032$). PCB in eggs and carcasses decreased from approximately 7 ppm ww to 1 ppm ww (Fig. 2B). Mean concentrations of PCBs by location (Fig. 3B) also negatively correlated ($r^2 = 0.35$, 13 df, $P = 0.019$) with sampling year. The decline of PCBs in birds with year was significant in specimens from Corpus Christi, but not in specimens from Port Mansfield and from Laguna Vista, where concentrations were much lower than in Corpus Christi (Fig. 3B).

Laughing Gull

A total of 310 samples (81% eggs, 19% carcasses) of laughing gulls was analyzed from 1970 to 1981 (King et al. 1978; King and Krynitsky 1986; White et al. 1983a, 1983b). The samples were primarily from Corpus Christi, Port Mansfield, Laguna Vista, and Galveston Bay.

DDE and PCB residues in eggs of laughing gulls decreased from 1970 to 1981, however, the concentrations of DDE and PCBs among locations within years were variable. Nonetheless, a plot of the annual geometric means revealed a significant negative correlation between DDE in eggs and year of

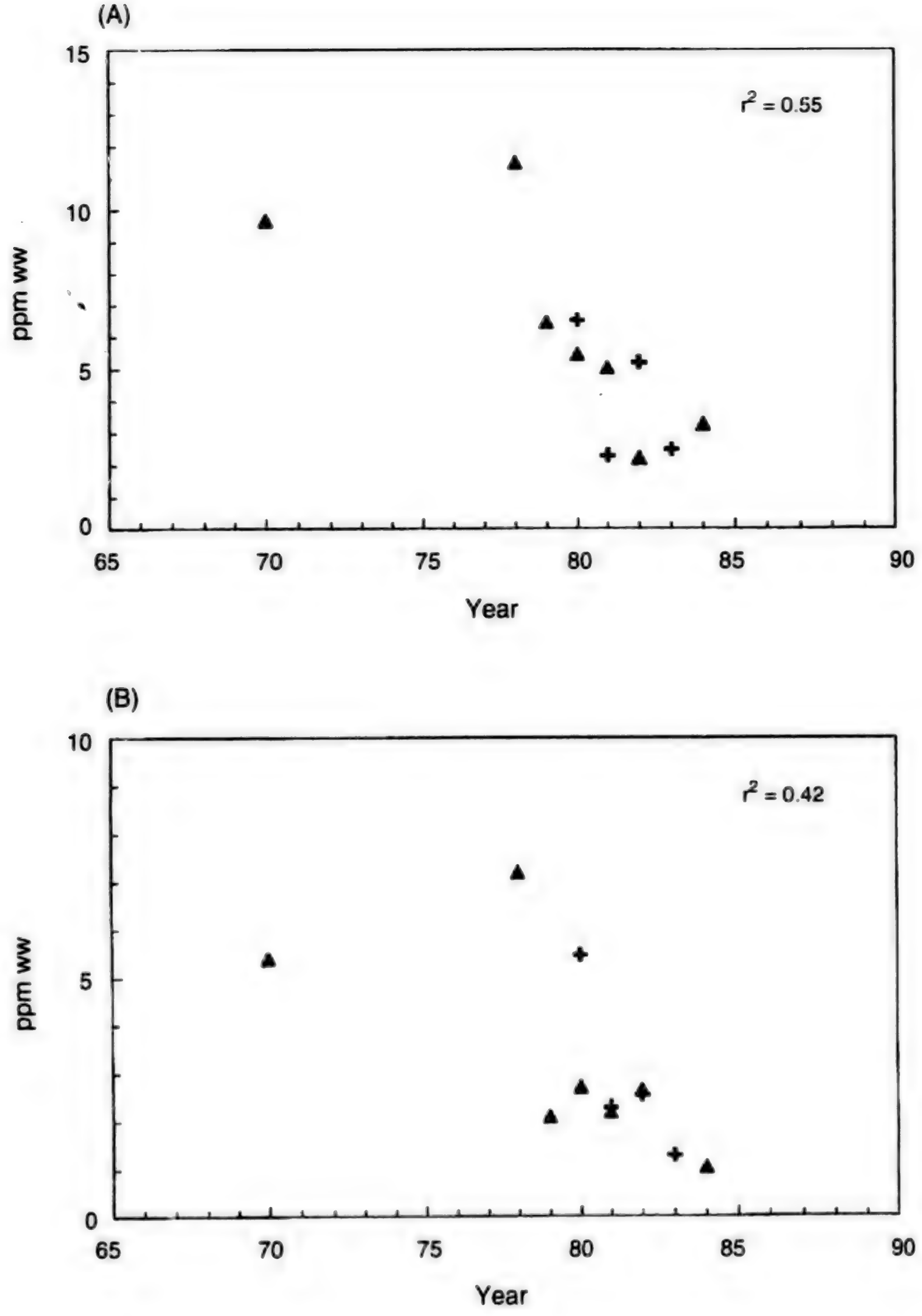

Fig. 2. DDE (A) and PCB (B) residues in eggs (▲) and carcasses (+) of black skimmers (*Rynchops niger*) from the Texas Gulf coast, 1970–84. Annual geometric means, $n = 411$.

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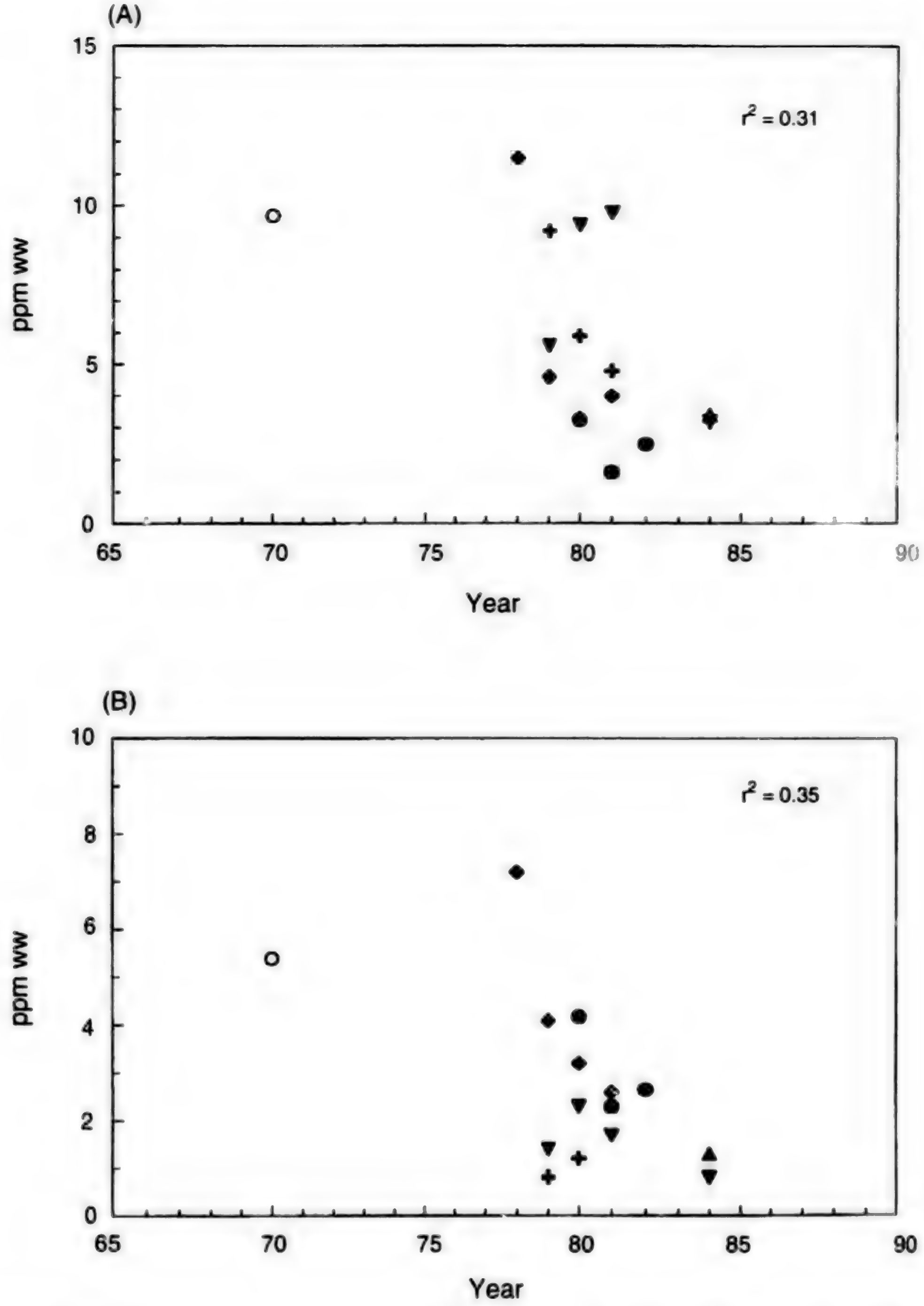

Fig. 3. DDE (A) and PCB (B) residues (geometric means) by location in eggs of black skimmers (*Rynchops niger*) from the Texas Gulf coast, 1970–84 ($n = 366$). Galveston Bay (●), Lavaca Bay (▲), Corpus Christi (◆), Port Mansfield (+), Laguna Vista (▼), Unknown (○).

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sampling ($r^2 = 0.92$, 4 df; $P = 0.002$; Fig. 4A). The decline of DDE concentrations in carcasses, however, was not apparent (Fig. 4B) and could not be determined because only median values were available from specimens during 1978–79. PCBs in eggs did not decrease significantly ($r^2 = 0.6$, 4 df, $P = 0.07$, Fig. 4A). DDE concentrations in eggs decreased from approximately 10 ppm to less than 1 ppm; PCBs diminished from about 3.0 ppm to nearly 1.5 ppm (Fig. 4A).

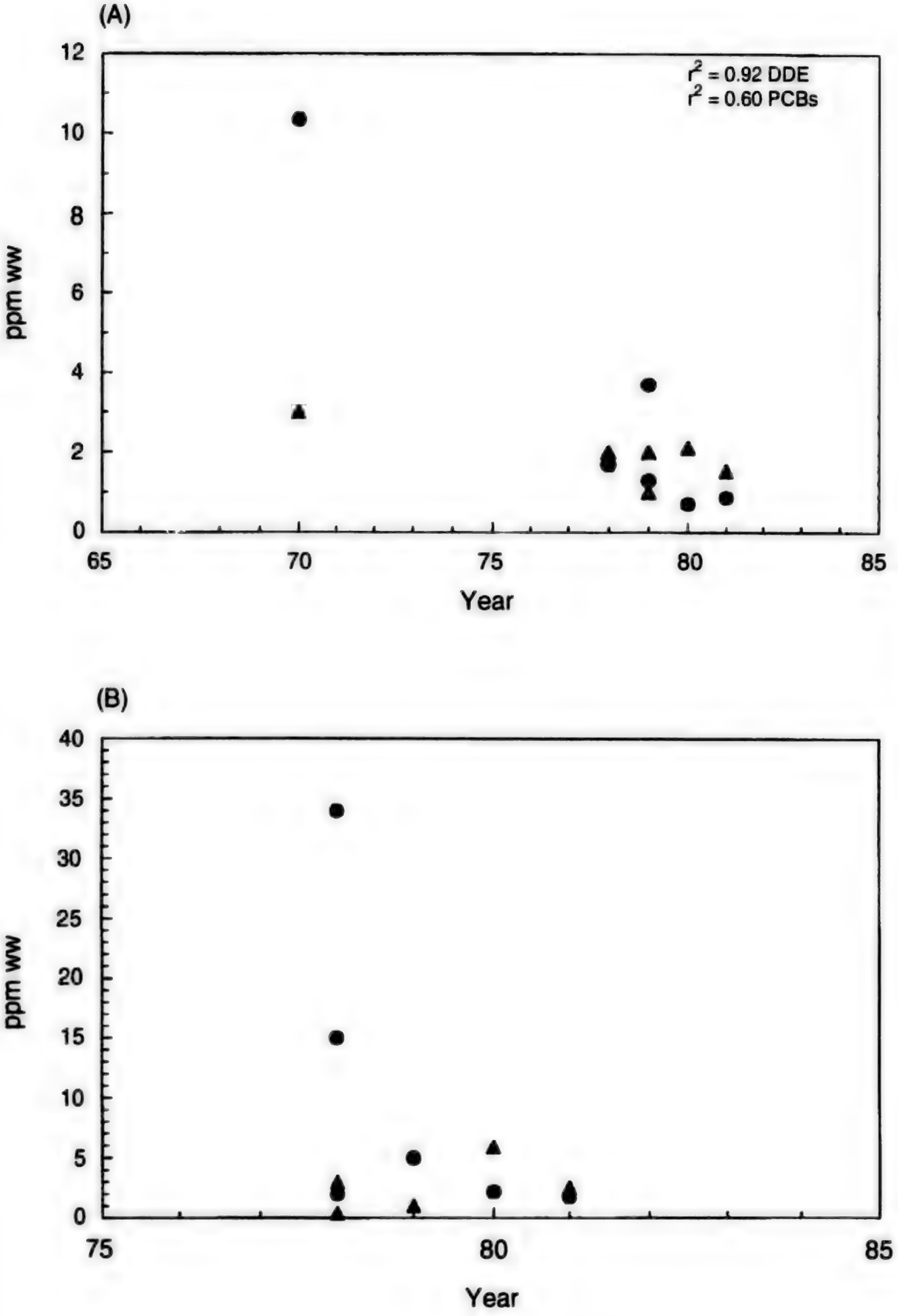

Fig. 4. DDE (●) and PCBs (▲) in eggs (*A*, *n* = 251, geometric means) and carcasses (*B*, *n* = 59, median values in 1978 and 1979, geometric means in 1980 and 1981) of laughing gulls (*Larus atricilla*) from diverse locations.

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Brown Pelican

Brown pelican eggs ($n = 114$) were collected during 1970 and from 1974 to 1981 from numerous locations along the Texas Gulf coast (King et al. 1977, 1978, 1985). Because only addled eggs or eggs from abandoned nests were collected, the number of collected eggs per colony was limited. Therefore, the geometric mean was composed of the total number of collected eggs per year. PCB but not DDE concentrations declined significantly over time ($r^2 = 0.67$, 7 df, $P < 0.01$; $r^2 = 0.26$, 7 df, $P > 0.05$; Fig. 5). Overall, DDE concentrations in eggs varied from more than 3 ppm ww in 1970 to approximately 1 ppm ww in 1983. The mean in 1974 (0.86 ppm ww) was, however, less than the mean in 1983 (1.30 ppm ww). PCB concentrations diminished from about 10 ppm ww to 1 ppm ww (Fig. 5). On average, PCB concentrations were 1.6 times higher than DDE concentrations. It is important to notice that concentrations of DDE and PCBs may have been biased towards higher values because only addled eggs were collected at all times.

Peregrine Falcon

Blood from migrating peregrine falcons (154 females, 3 males) was collected on South Padre Island during 1978, 1980, and 1984 (Henny et al. 1988). Peregrine falcons were captured during spring migration from their wintering grounds in Latin America. These birds were mostly transient in Texas because they winter primarily in Latin America and nest in Canada and Alaska. DDE concentrations in plasma from 1978 to 1984 did not decrease ($r^2 = 0.46$, 4 df, $P = 0.136$; Fig. 6). DDE concentrations dropped from about 1.5 ppm ww in 1978 to less than 0.5 ppm ww in 1980 but remained stable between 1980 and 1984. Peregrine falcons that were captured on South Padre Island during fall migration in 1976–79 were mostly (85%) hatch-year birds on their first migration to Latin America (Henny et al. 1982). These birds had low organochlorine residues and were not included in the analysis of trends.

European Starling

From 1967 to 1985, the U.S. Fish and Wildlife Service conducted nationwide monitoring in which carcasses from European starlings were collected from selected locations in the contiguous United States every 2–3 years for organochlorine analyses (Martin 1969; Martin and Nickerson 1972; Nickerson and Barbehenn 1975; White 1976, 1979b; Cain and Bunck 1983; Bunck et al. 1987; Bunck unpublished). A total of 347 starlings was collected from several Texas counties, but sufficient data for statistical analysis were available only from Clay, Cochran, Comal, Kinney, and San Patricio counties.

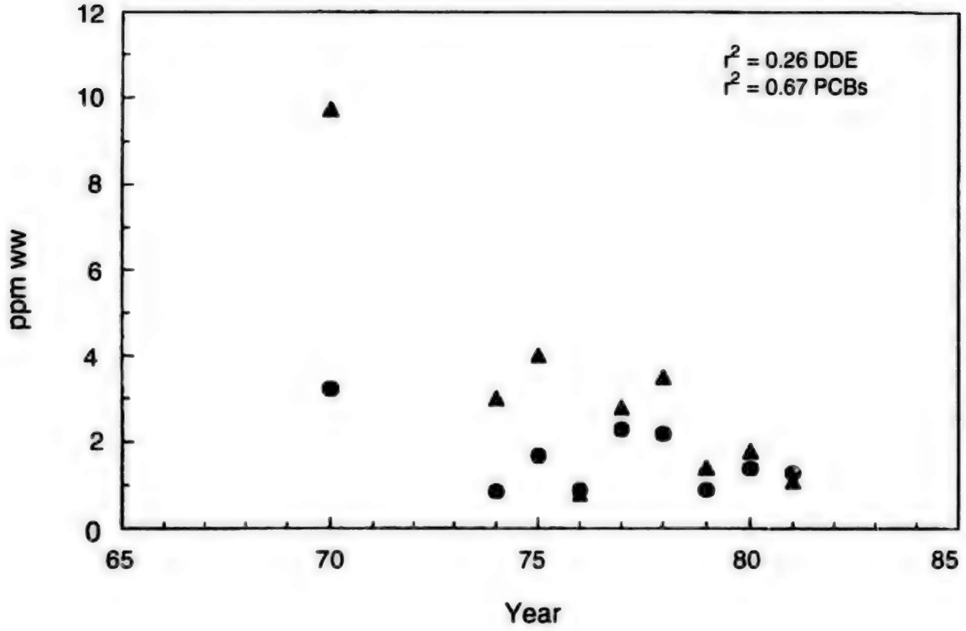

Fig. 5. DDE (●) and PCBs (▲) in eggs (geometric means) of brown pelicans (*Pelecanus occidentalis*) from the Texas Gulf coast, 1970–81. $n = 114$, specific locations were not disclosed.

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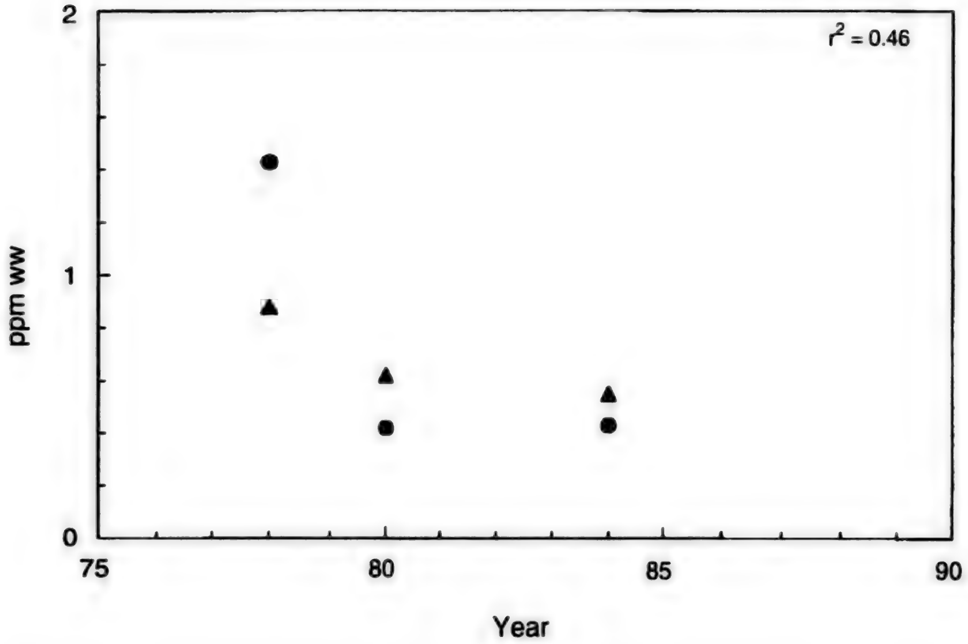

Fig. 6. DDE in plasma of peregrine falcons (*Falco peregrinus*) captured during spring migration at South Padre Island, Texas. (*n* = 154 females, geometric means). Second year females (●), After second year females (▲).

Variability in organochlorine concentrations in starlings was great within and among years, and among counties (Fig. 7). DDE body burdens were significantly reduced only in starlings from Comal County and were nearly significantly reduced in starlings from San Patricio County. In Comal County, DDE concentrations in starlings decreased from more than 1 ppm in 1972 to nearly 0.1 ppm in 1985 (r^2 = 0.96, 2 df, *P* = 0.021); and from about 1 to 0.2 ppm in starlings from San Patricio County (r^2 = 0.69, 3 df, *P* = 0.08). DDE concentrations in starlings from Clay, Cochran, and Kinney counties were without

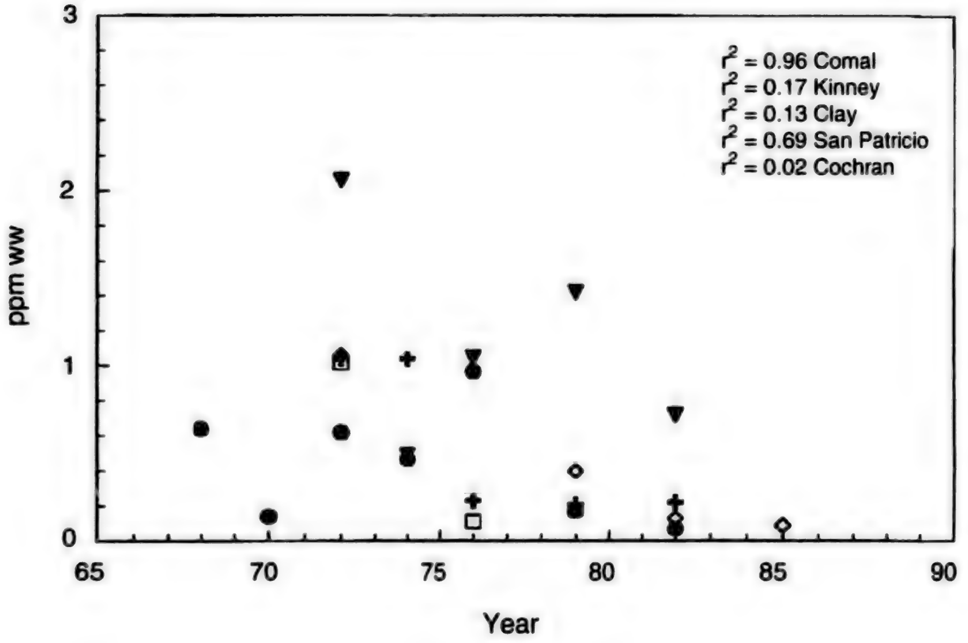

Fig. 7. DDE in pooled carcasses of European starlings (*Sturnus vulgaris*) from Texas. Mean values are given by counties. Comal (◇), Kinney (▼), Clay (●), San Patricio (+), and Cochran (□).

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statistically significant trends of decline. Overall, the available multiple data points from the continuous monitoring of starlings in Texas point out the great temporal variability that may occur in residue concentrations even in a single species in one given area.

Neotropic Cormorant

Neotropic cormorants (*Phalacrocorax brasilianus*) were sampled sporadically during the 1970s and 1980s (King et al. 1978; Morrison 1978; King and Krynitsky 1986; King 1989a). Forty-three eggs and 20 carcasses were collected during 4 years (Fig. 8). Concentrations of DDE and PCBs in eggs did not decline from 1970 to 1981 ($r^2 = 0.78$, 2 df, $P = 0.115$; $r^2 = 0.82$, 2 df, $P = 0.094$). PCB concentrations were on average 4.5 times higher than DDE concentrations. The cormorant eggs collected in 1970 were from several colonies along the coast, and eggs and carcasses collected during 1980 and 1981 were from the Galveston Bay. Except for the high value of PCBs in 1970, the concentrations of PCBs were below 5 ppm in eggs and below 8 ppm in carcasses. Concentrations of DDE in eggs were also highest in 1970 (Fig. 8).

Mallard

Organochlorine pesticides were monitored nationwide in wings and carcasses of mallards (*Anas platyrhynchos*) and American black ducks (*A. rubripes*) from 1965 to the mid-1980s (White and Heath 1976; White 1979a; Cain 1981; White and Krynitsky 1986; Flickinger and Krynitsky 1987). Mallards (46 wings, 34 carcasses) were collected from several sites in Texas. Except for one high value in 1969 (0.98 ppm), DDE residues in wings were below 0.4 ppm and did not decline in Texas during 1965–82 (Fig. 9). DDE concentrations in carcasses (geometric means) were also low (≤ 0.2 ppm). PCB concentrations in wings and carcasses were relatively low (range 0.05–0.20 ppm ww, not shown in figure) and data were available for only few years.

Roseate Spoonbill

Eggs ($n = 80$) of roseate spoonbills (*Ajaia ajaja*) were collected during 1970–80 at the Nueces Bay and in other locations along the Gulf coast (King et al. 1978; White et al. 1982). Reduced concentrations of DDE and PCBs in eggs seemed apparent, however, the data from 1977 and 1980 were median values, whereas the data from 1970 were arithmetic means (Fig. 10). Both DDE and PCB concentrations decreased during the 10-year period by a factor of 4; DDE decreased from about 4 to nearly 1 ppm ww, and PCBs diminished from more than 2 to about 0.5 ppm ww (Fig. 10).

White-faced Ibis

White-faced ibis (*Plegadis chihi*) eggs ($n = 63$ individual eggs, 4 clutches) were collected during 1970,

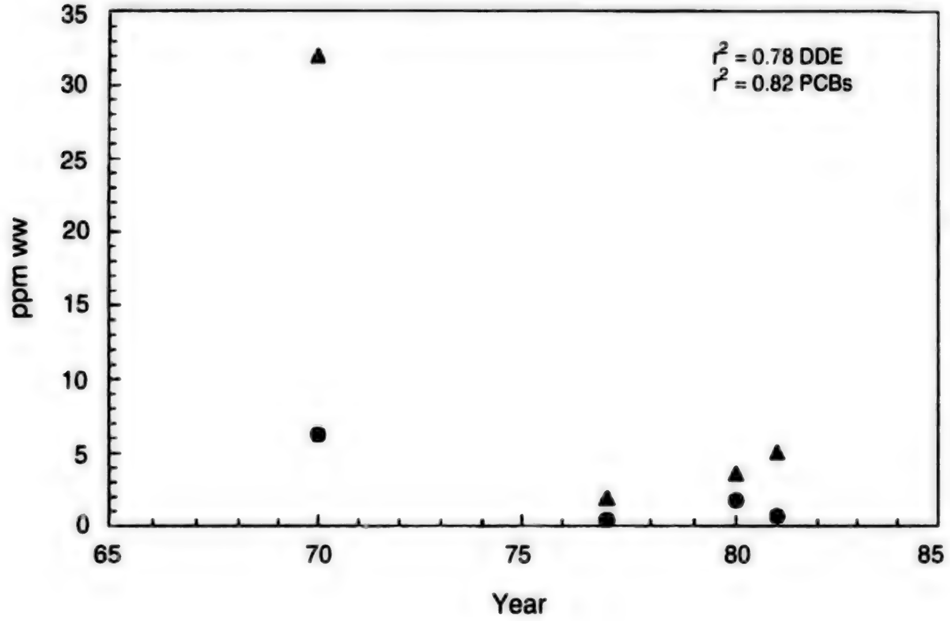

Fig. 8. DDE (●) and PCBs (▲) in eggs (geometric means) of neotropic cormorants (Phalacrocorax brasilianus) from the Galveston Bay and from an undisclosed location. $n = 43$.

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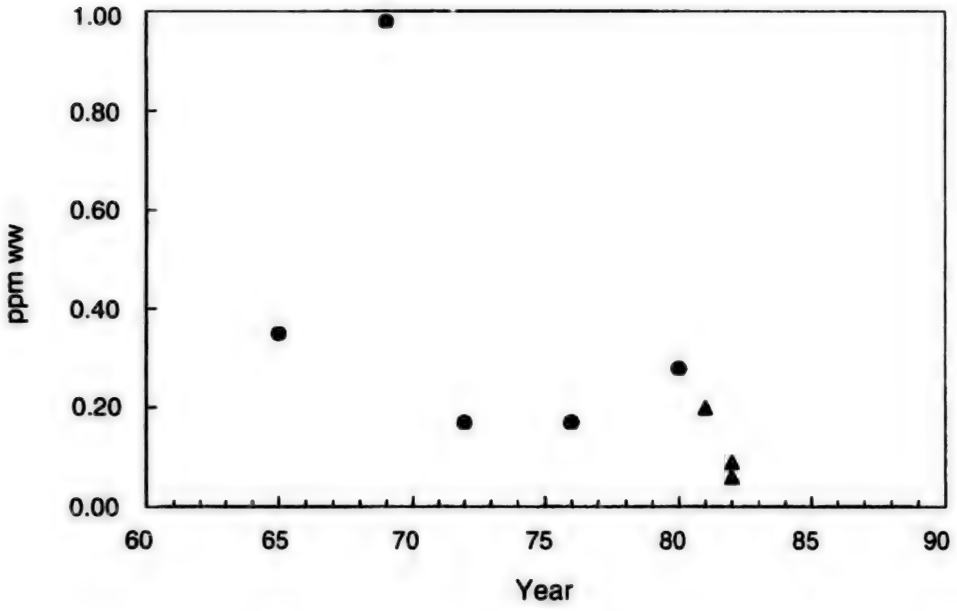

Fig. 9. DDE in pooled wings (●) and carcasses (▲) of mallards (*Anas platyrhynchos*) from Texas. $n = 46$ wings (arithmetic means), 34 carcass (geometric means).

1971, 1976, and 1985 along the Gulf coast (King et al. 1978, 1980; Custer and Mitchell 1989). DDE contents in birds did not decrease with sampling during 1970–76 (Fig. 11). DDE values were similar during 1976 and 1985. Average DDE concentrations were six to eight times higher during 1970–71 than during 1976 and during 1985. However, the high level in 1970 was from thin-shelled eggs, and the value in 1971 was from a clutch with collapsed eggs (King et al. 1980). PCBs were only reported in 1970 and in 1976 and were equal to or below 1.5 ppm ww.

Great Blue Heron

Great blue heron (*Ardea herodias*) eggs ($n = 53$) were collected during 1970, 1978, and 1979 at the Nueces Bay ($n = 33$) and in other locations of the Gulf coast ($n = 20$; King et al. 1978; Mitchell et al. 1981). DDE and PCB concentrations decreased be-

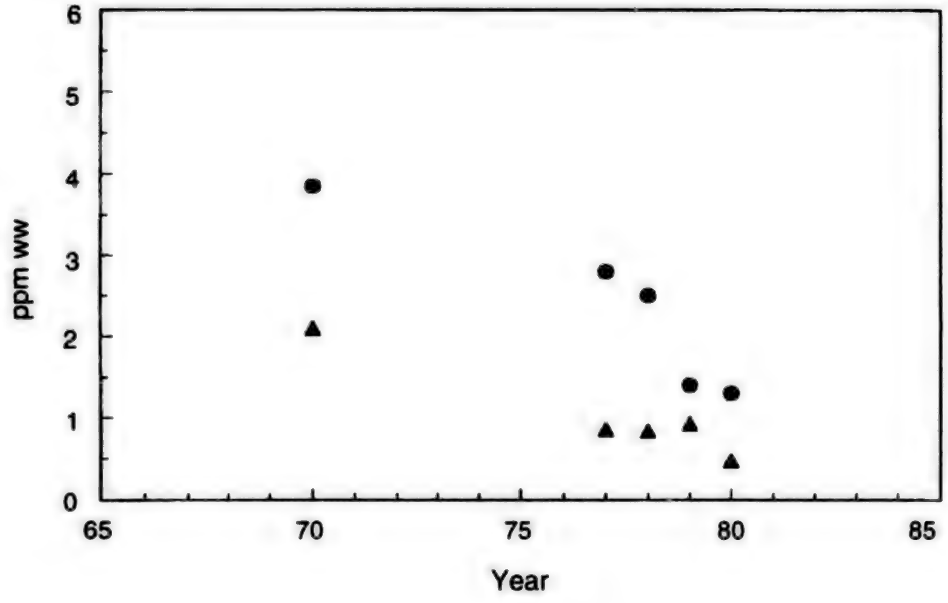

Fig. 10. DDE (●)and PCBs (▲) in eggs of roseate spoonbills (*Ajaia ajaja*) from the Nueces Bay (median values) and from one undisclosed location in 1970 (arithmetic mean). $n = 80$.

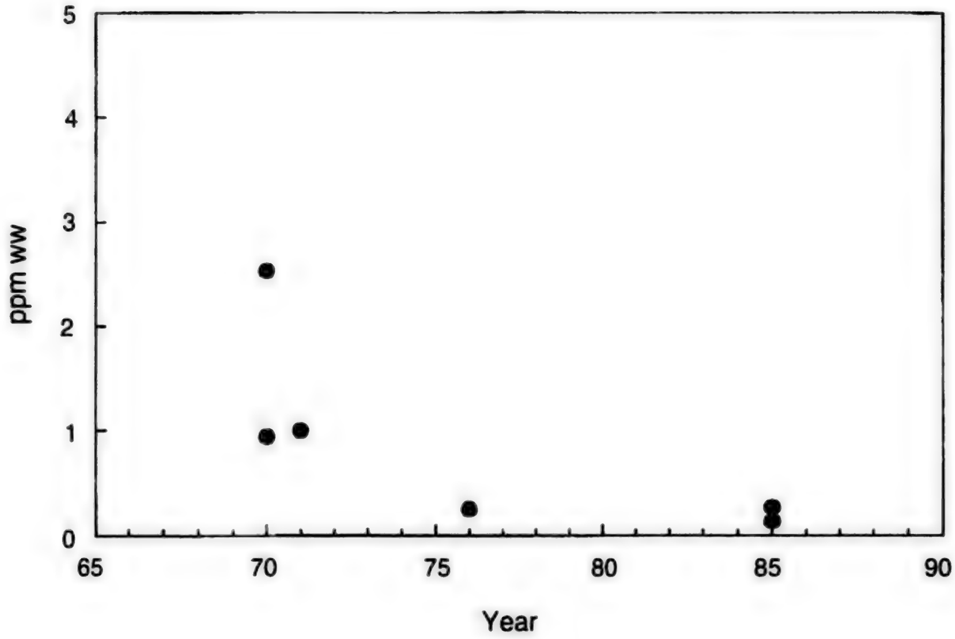

Fig. 11. DDE in eggs of white-faced ibises (*Plegadis chihi*) from the Texas Gulf coast. *n* = 63 individual eggs (arithmetic means, geometric mean in 1985), and 4 full clutches. One pooled full clutch with abnormal eggs had an average of 6.5 ppm ww.

tween 1978 and 1979, however, a trend from 1970 to 1979 could not be established because only arithmetic mean or median values were provided from different years. Concentrations of PCBs were two times higher than concentrations of DDE in eggs of great blue herons during the last two sampling periods. DDE concentrations decreased from nearly 6 to 3 ppm, but PCBs remained stable during the sampling period.

Other Species

Sufficient data for the analysis of trends were not available of many species. Most data (Appendix) were from carcasses that were collected during 1977–88. As expected, variability in DDE and PCB concentrations among species and among years was great. Relatively high DDE concentrations (mean range = 14.0–28.5 ppm ww) in carcasses were reported from several species during 1978 (White et al. 1983a) and 1982 (Hunt et al. 1986) and from a single bird (46.0 ppm) in 1985 (L. R. Gamble, G. Jackson, and T. C. Maurer, 1988. Organochlorine, trace element, and petroleum hydrocarbon contaminants investigation of the lower Rio Grande valley, Texas, 1985–86. U.S. Fish and Wildlife Service, Ecological Services, Corpus Christi, Texas, unpublished report). Single DDE values during 1978 and 1982 were as high as 81 ppm (see White et al. 1983 and Hunt et al. 1986 for details) and are among the highest concentrations ever reported in carcasses of birds from Texas. DDE concentrations in eggs were also relatively high (range 0.4–23.2 ppm ww) during 1970 but decreased considerably during 1978, 1983, and 1986. Eggs collected during 1970 were abandoned or thin-shelled, thus DDE concentrations may have been higher than in normal eggs (King et al. 1978).

Trends of DDE and PCB Concentrations in Birds from Selected Regions

Because of the diversity of data from several species in each region, only the slopes of the curves are presented (Figs. 12–14). In all cases, the slopes were negative, suggesting a trend of declining concentrations of DDE and PCBs in birds.

Galveston Bay

Concentrations of organochlorine contaminants in birds from the Galveston Bay area were available from several species during 1980–1983 (Figs. 12A and 12B; King et al. 1983, 1987; King and Krynitsky 1986). The same species—black skimmer, laughing gull, and neotropic or double-crested cormorant—were sampled similarly during a 3-year period. Only carcasses of

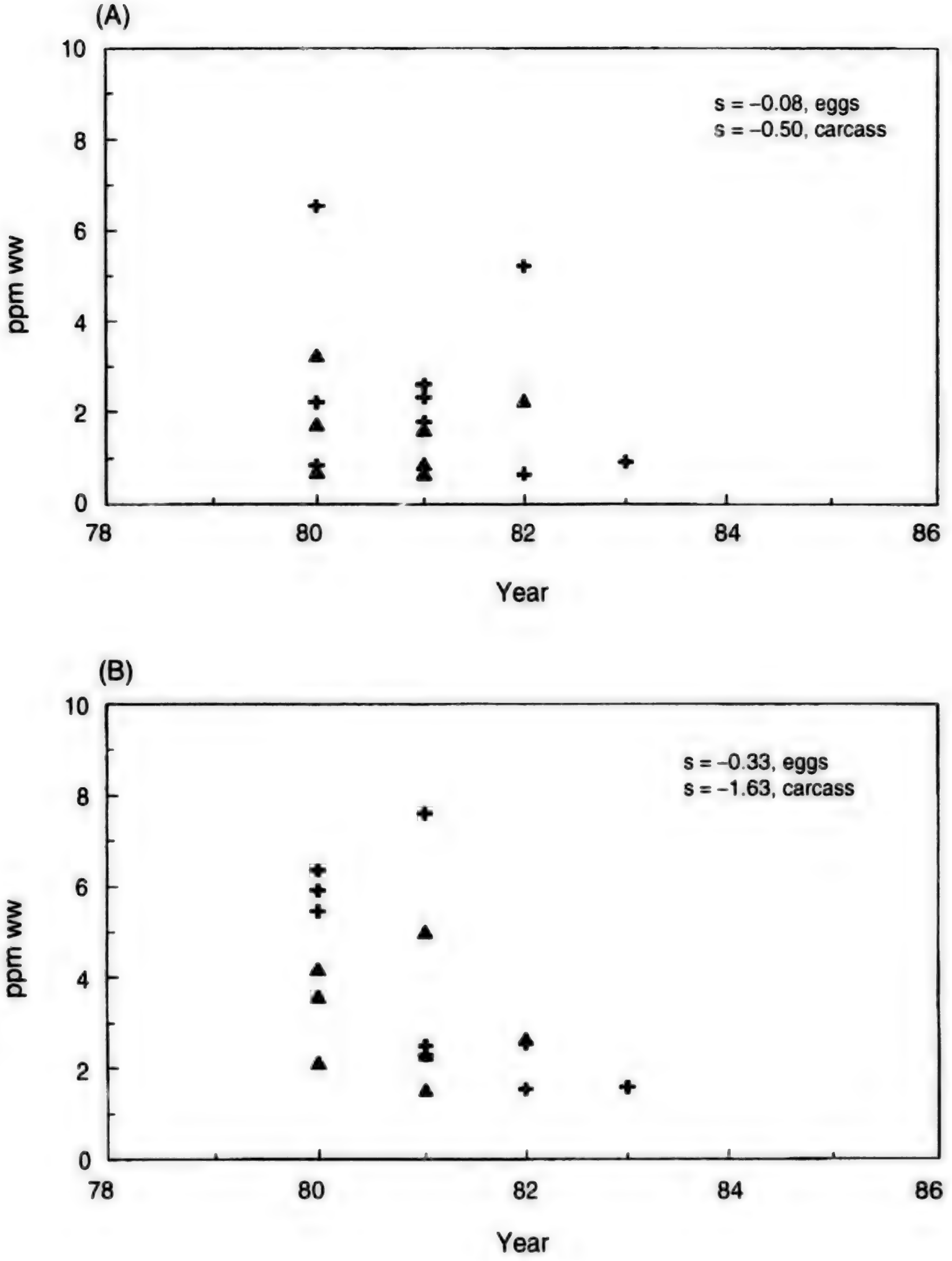

Fig. 12. DDE (A) and PCBs (B) in eggs (▲) and carcasses (+) of birds from the Galveston Bay (geometric means). S = slope of regression line.

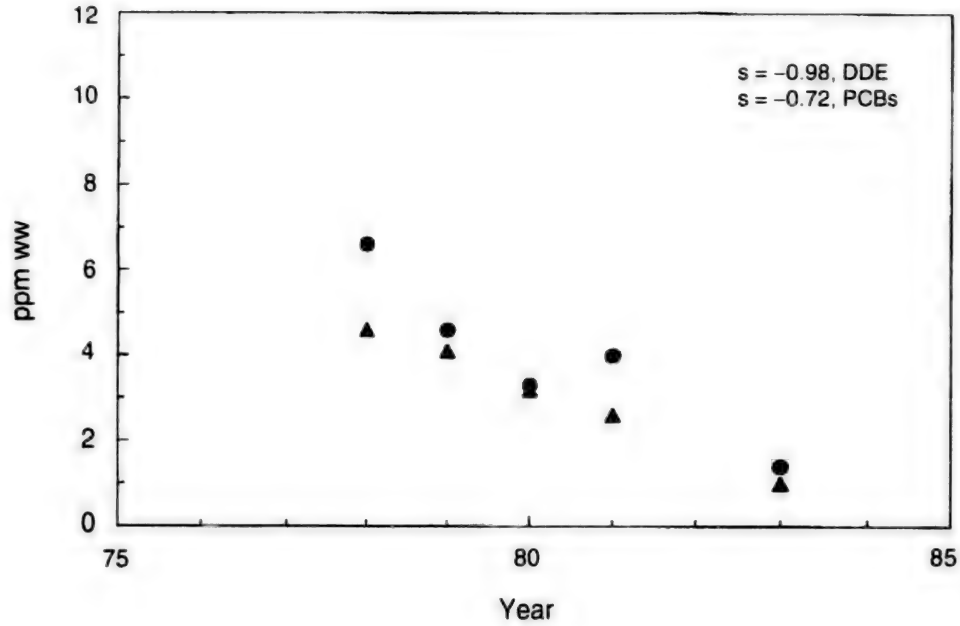

Fig. 13. DDE (●) and PCBs (▲) in eggs (geometric means) of birds from Corpus Christi. *S* = slope of regression line.

double-crested cormorants were collected in 1983. Concentrations of DDE in eggs remained unchanged during the 3 years, but concentrations of DDE in carcasses seemed to decline somewhat as suggested by the more pronounced negative slope (Fig. 12A). The slopes of PCB concentrations were clearly more negative than the slopes of DDE concentrations (Fig. 12B). PCBs in carcasses decreased from about 6.0 ppm to 1.5 ppm, but concentrations in eggs did not change much during the 4 years of sampling.

Corpus Christi Bay

Fewer data were available of birds from Corpus Christi than of birds from the Galveston Bay (White

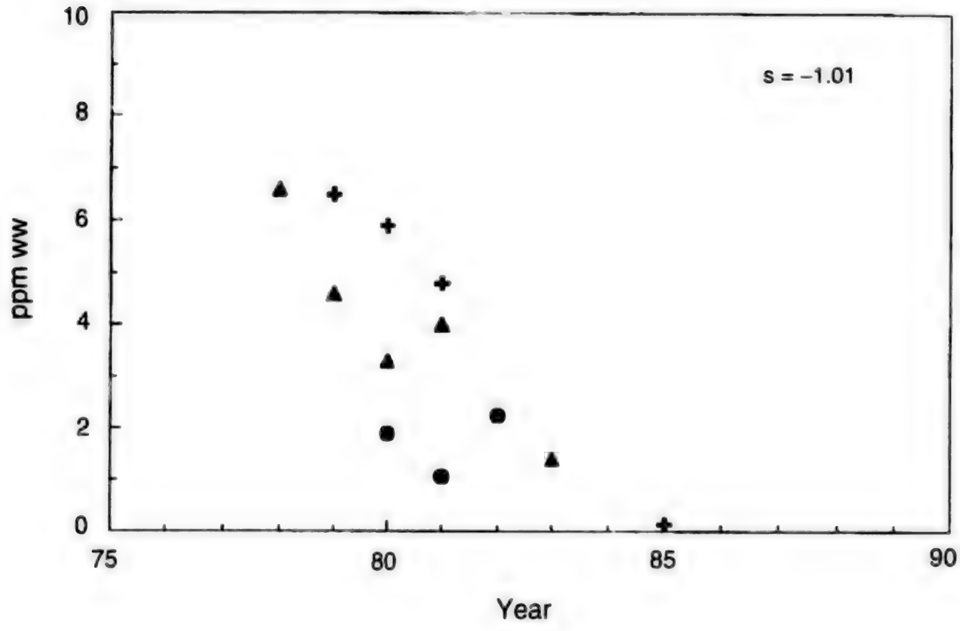

Fig. 14. DDE in eggs (geometric means) of birds from Galveston (●), Corpus Christi (▲), and Port Mansfield (+). *S* = slope of regression line.

et al. 1980, 1983b, 1984; White and Krynitsky 1986). Most data were of black skimmers (67%). Additional data were of black-crowned night-herons (*Nycticorax nycticorax*, 17%) and of laughing gulls (17%). DDE and PCB trends in eggs of birds from Corpus Christi were similar. Both regression lines had negative slopes near −1, suggesting a trend of decreasing concentrations from 1978 to 1983 (Fig. 13). From 1978 to 1983, DDE diminished from near 7 to about 1 ppm DDE. PCBs decreased from nearly 5 to less than 1 ppm.

Gulf Coast

Concentrations of DDE in eggs of birds from the Galveston Bay, from Corpus Christi, and from Port Mansfield were used for the analyses of trends in coastal birds. Seventy-one to 83% of the mean values from each region were represented by two species, the black skimmer and the laughing gull. Additionally, concentrations of DDE in eggs were not different among regions. Thus, mean concentrations of DDE and PCBs were comparable and were representative of trends in the Texas Gulf coast. As in other cases, the slope of the regression line was negative, suggesting a trend of decreasing concentrations of DDE with sampling year. Concentrations of DDE in eggs of birds from the three Texas coast locations decreased from more than 6 ppm in 1978 to less than 0.5 ppm in 1985. Data on PCBs in eggs or carcasses were insufficient to assess a trend.

DDE and PCB Ratios

The ratio between the mean DDE or PCB concentration (mostly in eggs) during the first or earliest year of sampling and the mean concentration during the last year were obtained of selected species (Table 6). Except in laughing gulls, DDE concentrations decreased by a factor that ranged from 2.0 to about 5.0, and PCB concentrations decreased by a factor from 4.5 to about 9.0. The overall mean decreasing factor in selected species was 3.2 of DDE and 6.3 of PCBs. In the laughing gull, the ratios were much higher of DDE than of PCBs for an unknown reason (Table 6). The mean decreasing factors of DDE and PCBs in the remaining species were close to the general mean decreasing factor of selected species.

Discussion

The analysis of trends of concentrations of DDE and PCBs in selected species of birds from Texas and from locations along the Gulf coast suggested that, in general, DDE and PCBs diminished in birds from Texas since 1965–88. Organochlorine concentrations in birds seem to have reached their lowest levels since the years when DDT and other persistent organochlorines were still in use. This trend of decreasing DDE and PCBs in birds was expected because the use of these organochlorines has been suspended for more than 15 years. Except in some areas in the southwestern United States (White and Krynitsky 1986), similar trends of decreasing organochlorine concentrations in birds have been observed throughout most parts of North America (Baumann and Whittle 1988; C. Bishop and D. V. Weseloh, 1990. Contaminants in herring gull eggs from the Great

Table 6. Decreasing DDE and PCB ratios in birds that were most commonly sampled in Texas.[a]

Species	Time interval first year–last year	DDE	PCBs	Tissue
Brown pelican	70–81	2.5	8.8	eggs
Great blue heron	70–89	1.9		eggs
White-faced ibis	70–85	4.7		eggs
Roseate spoonbill	70–80	3.0	4.5	eggs
Peregrine falcon	78–84	3.3		plasma
Laughing gull	70–81	11.8	2.0	eggs
Black skimmer	70–84	3.5	6.9	eggs
European starling	68–85	2.9		carcass
Mean		3.2	6.3	
S.D.		0.85	3.0	

[a] Ratios were obtained by dividing the overall mean in the earliest year by the mean in the last year of sampling.

Lakes. State of the environment fact sheet 90-2, Environment Canada, unpublished report). The occurrence, however, of persistent DDE in nearly 100% of the samples, even during recent years, suggested that DDE is still found in the environment as a result of the widespread use of DDT in the past. Widespread use in the past and atmospheric deposition from other areas (Rapaport et al. 1985) probably account for most of the current DDE in wildlife tissues. Similarly, the high frequency of PCBs in samples from Texas may be explained by atmospheric deposition, long persistence (Rapaport and Eisenreich 1988), and some possible local sources. Although PCBs decreased in birds from Texas during the 1980s, many potential sources still remain, particularly from industries near the coast and along the Lower Rio Grande (Brownsville Economic Development Council, 1990. Directory of Manufacturers and processors, Brownsville, Texas, U.S.A. The Brownsville Economic Development Council, Inc., unpublished data). Atmospheric deposition of PCBs in the Gulf of Mexico may also be a source of PCBs for many wildlife species.

The concentrations of DDE and PCBs observed in earlier years (late 1960s and 1970s) in birds from Texas may have had negative effects on some species. Brown pelicans, for example, are one of the most sensitive species to eggshell thinning from DDE; levels as low as 3 ppm ww in eggs can cause significant eggshell thinning and low reproductive success (Blus 1982). Brown pelicans had disappeared from Louisiana by 1963, and an average of only 100 individuals was observed along the Texas coast annually during 1967–74 (King et al. 1977, 1985). Mean DDE levels in eggs of brown pelicans during 1970 were at the threshold of eggshell thinning, suggesting that DDE probably played a major role in the decline of brown pelicans along the Texas Gulf coast (Blus 1982).

The white-faced ibis seems to be also sensitive to DDE. Concentrations in eggs above 4 ppm negatively affected productivity in a colony at Carson Lake, Nevada (Henny and Herron 1989). DDE concentrations in eggs of white-faced ibises from Texas were near the critical level (4 ppm) during 1970. The biological effects of DDE on other species are not as clear. For example, mean DDE concentrations of 3.2 ppm ww in eggs of black skimmers correlated with decreased hatching and fledgling successes (Custer and Mitchell 1987). However, higher DDE concentrations of about 10 ppm did not seem to affect productivity of black skimmers from similar areas along the Texas coast (White et al. 1984).

The levels of PCBs in brown pelicans and in neotropic cormorants from the Gulf coast were also high during 1970 and perhaps contributed to poor reproductive success during the early 1970s. PCBs at concentrations of 4 ppm ww in eggs of bald eagles (*Haliaeetus leucocephalus*) of the Great Lakes have been associated with adverse effects on reproduction (T. J. Kubiak and D. A. Best, 1991. Wildlife risks associated with passage of contaminated, anadromous fish at Federal Energy Regulatory Commission licensed dams in Michigan. U.S. Fish and Wildlife Service, Ecological Services, East Lansing, Michigan, unpublished report).

I emphasize that even when the data suggest a decreasing trend in some species and locations, elevated concentrations of these highly persistent organochlorines may still be found in some hot spots, such as those found earlier in Hudspeth, Presidio, and Reeves counties (Hunt et al. 1986) and along the lower Rio Grande valley (White et al. 1983). Furthermore, even though the use of organochlorines in agriculture has decreased considerably, the battle to control agricultural pests has not stopped, and newer and more toxic compounds are currently used (TAES, personal communication). Organophosphorus and carbamate insecticides are used intensively in agriculture and often have deleterious effects on wildlife (Smith 1987). Organophosphorus and carbamate insecticides are less persistent than organochlorines, thus, they are more difficult to detect in biological samples unless samples are analyzed soon after exposure (Smith 1987). Also, increased industrial development in urbanized areas along the Gulf coast and the Rio Grande River Valley has resulted in continuous exposure of wildlife to other highly persistent and toxic chlorinated hydrocarbons including PCBs, polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). These halogenated hydrocarbons are highly toxic and teratogenic (Nikolaidis et al. 1988; Brunstrom 1991) and are hazardous to birds in sufficient exposure. Recently, three deformed nestling birds were found on the National Audubon Society sanctuary islands of the Lower Laguna Madre (S. Thompson and A. Plummer, personal communication), however, none of the above named organochlorines has yet been associated with those deformities.

Much remains to be done to determine the effects of new generation insecticides and industrial contaminants on bird populations in Texas. Dicofol, one of the few organochlorines still in use, is applied in orchards and to other crops in southern Texas (Clark 1990), thus, the possible effects of dicofol on eggshell thinning and on reproduction in birds from this area must be evaluated. The concentrations of persistent organochlorine insecticides have diminished considerably in birds from Texas from the harmful levels during the 1960s and 1970s to lower concentrations that probably do not represent a hazard or present only a reduced hazard to the healthy reproduction of most species. Careful interpretation of these results is necessary, however, because reproductive, teratogenic, and behavioral effects are species-specific and depend for the most part on the concentrations in the ecosystem that is inhabited by a particular species at a particular time.

Concentrations of DDE and PCBs in birds from Texas seem to have declined from the late 1960s to the present, however, this suggestion should be taken with caution because the same locations were not monitored in a continuous manner and most of the observed differences could be species and time related. Trends of declines would be best observed at a local level from the analysis of long-term contaminant data from a single species.

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Appendix. DDE and PCB concentrations (sorted by year) in birds not included in figured trends.

Species	*n*	Year[a]	ppDDE	PCBs	Location	Reference
Carcasses						
Blue-winged teal	31	77	0.48		Powderhorn Lake	White et al. 1981
Dunlin	13	77	3.15	1.19	Corpus Christi	White et al. 1980
Greater yellowlegs	2	77	1.90	0.97	Corpus Christi	White et al. 1980
Least sandpiper	30	77	1.07	0.67	Corpus Christi	White et al. 1980
Lesser yellowlegs	17	77	4.55	0.79	Corpus Christi	White et al. 1980
Sanderling	15	77	4.76	6.64	Corpus Christi	White et al. 1980
Blue-winged teal	3	78	0.38		Powderhorn Lake	White et al. 1981
Blue-winged teal	27	78	0.38		San Bernard NWR	White et al. 1981
Franklin's gull	6	78	9.00	0.70	Llano Grande Lake	White et al. 1983a
Great-tailed grackle	10	78	14.00		Llano Grande Lake	White et al. 1983a
Herring gull	2	78	5.00		South Padre Island	White et al. 1983a
Pied-billed grebe	2	78	6.00	4.00	Llano Grande Lake	White et al. 1983a
Ring-billed gull	12	78	3.00	4.00	South padre Island	White et al. 1983a
Ring-billed gull	14	78	8.00	0.90	Llano Grande Lake	White et al. 1983a
Red-winged blackbird	1	78	4.50		Llano Grande Lake	White et al. 1983a
Long-billed dowitcher	20	79	5.70		Port Mansfield	White et al. 1983c
Long-billed dowitcher	20	79	2.80		Port Mansfield	White et al. 1983c
Long-billed dowitcher	15	80	5.50		Port Mansfield	White et al. 1983c
Green-winged teal	10	81	0.17		Playa Lakes	Flickinger and Krynitsky 1987
Northern pintail	14	81	0.17		Playa Lakes	Flickinger and Krynitsky 1987
Double-crested cormorant	10	82	0.66	1.54	Galveston Bay	King et al. 1987
Kildeer	1	82	21.30		Presidio	Hunt et al. 1986
Western kingbird	3	82	61.00		Reeves/Hudspeth	Hunt et al. 1986
Barn swallow	1	82	2.00		Presidio	Hunt et al. 1986
Northern rough-winged swallow	1	82	0.50		Presidio	Hunt et al. 1986
Mourning dove	5	82	0.70		Reeves/Hudspeth	Hunt et al. 1986
Red-winged blackbird	3	82	28.50		Reeves/Hudspeth	Hunt et al. 1986
Great-tailed grackle	9	82	16.10		Reeves/Hudspeth	Hunt et al. 1986
Double-crested cormorant	10	83	0.93	1.58	Galveston Bay	King et al. 1987
House sparrow	9	83	2.00		Van Horn	King et al. 1987
House sparrow	69	83	1.00		Pecos River	King et al. 1987
House sparrow	30	83	1.40		Rio Grande	King et al. 1987
House sparrow	10	83	6.90		Presidio	King et al. 1987
House sparrow	10	83	1.30		Dell City	King et al. 1987
House sparrow	10	83	1.70		Pecos	King et al. 1987
House sparrow	10	83	1.60		Fabens	King et al. 1987
House sparrow	10	83	1.20		Balmorhea	King et al. 1987
Western kingbird	10	83	3.10		Dell City	King et al. 1987
Western kingbird	10	83	4.70		Balmorhea	King et al. 1987
Western kingbird	11	83	8.80		Van Horn	King et al. 1987

Appendix. *Continued.*

Species	*n*	Year[a]	ppDDE	PCBs	Location	Reference
Western kingbird	10	83	4.50		Pecos	King et al. 1987
Western kingbird	10	83	4.60		Fabens	King et al. 1987
Western kingbird	10	83	5.90		Balmorhea	King et al. 1987
Western kingbird	10	83	5.70		Dell City	King et al. 1987
Western kingbird	12	83	9.70		Pecos	King et al. 1987
Western kingbird	10	83	3.60		Presidio	King et al. 1987
Western kingbird	10	83	3.70		Fabens	King et al. 1987
Western kingbird	10	83	8.10		Van Horn	King et al. 1987
Black-necked stilt	3	85	3.30		Castro County	Gamble et al. 1988
American white pelican	1	85	46.10		Rio Grande	Gamble et al. 1988
Willet	18	86	0.95	0.30	Lag. Atascosa	Custer and Mitchell 1991
Willet	10	86	0.10	0.70	Bastrop Bayou	Custer and Mitchell 1991
Willet	7	86	0.20	0.40	South Padre Island	Custer and Mitchell 1991
Willet	20	86	1.30	1.30	Port Mansfield	Custer and Mitchell 1991
Redhead	18	88	0.66		Port Mansfield	Michot et al. 1994
Redhead	19	88	0.62		Port Aransas	Michot et al. 1994
Eggs						
Black-crowned night-heron	10	70	1.76		Texas Coast	King et al. 1978
Caspian tern	10	70	15.13	16.50	Texas Coast	King et al. 1978
Great egret	10	70	23.24		Texas Coast	King et al. 1978
Gull-billed tern	10	70	4.89	1.25	Texas Coast	King et al. 1978
Least tern	5	70	6.94	2.60	Texas Coast	King et al. 1978
Little blue heron	5	70	1.20	1.40	Texas Coast	King et al. 1978
Tricolored heron	5	70	6.50	2.40	Texas Coast	King et al. 1978
Royal tern	5	70	4.28	11.60	Texas Coast	King et al. 1978
Sandwich tern	5	70	1.12	1.40	Texas Coast	King et al. 1978
Snowy egret	10	70	3.26	2.03	Texas Coast	King et al. 1978
White ibis	5	70	0.41		Texas Coast	King et al. 1978
American white pelican	5	70	1.38	0.98	Texas Coast	King et al. 1978
Royal tern	20	78	1.13	0.75	Pelican Island	King et al. 1983
Royal tern	20	78	1.20	1.34	Sundown Island	King et al. 1983
Black-crowned night-heron	10	83	1.40	1.00	Corpus Christi	White and Krynitsky 1986
Barn swallow	2	86	0.58		Martin Lake	King et al. 1994
Other tissues[b]						
House sparrow (m)	80	65	6.20		Presidio	Culley and Applegate 1967
House sparrow (l)	80	65	4.70		Presidio	Culley and Applegate 1967
House sparrow (b)	80	65	3.20		Presidio	Culley and Applegate 1967

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[a] The collection of eggs during 1970 was biased towards the selection of thin-shelled eggs, thus, 1970 values may be higher than normal.

[b] m = breast muscle, l = liver, b = brain.

The following is a list of recent *Fish and Wildlife Research* publications.

1. Life History and Status of the Endangered Cui-ui of Pyramid Lake, Nevada, by G. Gary Scoppettone, Mark Coleman, and Gary A. Wedemeyer. 1986. 23 pp.
2. Spread, Impact, and Control of Purple Loosestrife (*Lythrum salicaria*) in North American Wetlands, by Daniel Q. Thompson, Ronald L. Stuckey, and Edith B. Thompson. 1987. 55 pp.
3. Taxonomy, Life History, and Ecology of a Mountain Mahogany Defoliator, *Stamnodes animata* (Pearsall), in Nevada, by Malcolm M. Furniss, Douglass C. Ferguson, Kenneth W. Voget, J. Wayne Burkhardt, Arthur R. Tiedemann, and John L. Oldemeyer. 1988. 26 pp.
4. Demographic Characteristics of a Maine Woodcock Population and Effects of Habitat Management, by Thomas J. Dwyer, Greg F. Sepik, Eric L. Derleth, and Daniel G. McAuley. 1988. 29 pp.
5. Premigrational Movements and Behavior of Young Mallards and Wood Ducks in North-central Minnesota, by Ronald E. Kirby, Lewis M. Cowardin, and John R. Tester. 1989. 25 pp.
6. Water and Habitat Dynamics of the Mingo Swamp in Southeastern Missouri, by Mickey E. Heitmeyer, Leigh H. Fredrickson, and Gary F. Krause. 1989. 26 pp.
7. Chironomidae of the Southeastern United States: A Checklist of Species and Notes on Biology, Distribution, and Habitat, by Patrick L. Hudson, David R. Lenat, Broughton A. Caldwell, and David Smith. 1990. 46 pp.
8. Forest Bird Habitat Suitability Models and the Development of Habitat Models, by Beatrice Van Horne and John A. Wiens. 1991. 29 pp.
9. Use of Wetland Habitats by Selected Nongame Water Birds in Maine, by James P. Gibbs, Jerry R. Longcore, Daniel G. McAuley, James K. Ringelman. 1991. 57 pp.
10. Wigeongrass (*Ruppia maritima* L.): A Literature Review, by Harold A. Kantrud. 1991. 58 pp.
11. Population Characteristics and Simulation Modeling of Black Ducks, by Warren Wayne Blandin. 1992. 200 pp.
12. Status of the American Eider with Special Reference to Northern New England, by William B. Krohn, Patrick O. Corr, and Alan E. Hutchinson. 1992. 12 pp.
13. Biology of North American Tortoises, edited by R. B. Bury and D. J. Germano. 1994. 204 pp.

NOTE: The mention of trade names does not constitute endorsement or recommendation for use by the Federal Government.

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U.S. Department of the Interior
National Biological Service

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This responsibility includes fostering the sound use of our lands and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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END

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